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The influence of vegetational type on seasonal abundance and species composition of soil fauna at different localities in Egypt

A. I. M. Al-Assiuty[1], B. M. Bayoumi[1], M. A. Khalil[1] and N. M. Van Straalen[2]

[1] Department of Zoology, Faculty of Science, Tanta University, Tanta, Egypt
[2] Department of Ecology and Ecotoxicology, Vrije Universiteit, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands

Summary. A comparative study has been made to investigate the influence of vegetational types on seasonal abundance and species composition of soil fauna at two different Governorates in Egypt, one bordering the Nile river, the other situated within the northern part of the Nile delta, close to the Mediterranean sea. The samples were taken each month from two different vegetational types (banana plantation and orange plantation) in each of the two studied areas for one year. Fauna extracted was pooled into four categories: oribatid mites, other Acari, Collembola and other fauna. Analysis of variance was applied for statistical analysis of the data. Community composition was determined throughout the period of study using the Shannon-Wiener index of diversity and Sørensen's quotient of similarity. The obtained results revealed that species diversity was similar among different vegetational types at the same sites and dissimilar between the same vegetational types at different sites. The monthly fluctuations of the total number of oribatid mites showed a gradual increase in orange orchards and a gradual decrease in banana orchards. Other Acari showed no significant differences in relation to site, vegetational types, time and the interactions among them. collembola revealed a significant difference between sites only and there was no obvious relationship between collembolan communities and vegetational types. From the results it may be concluded that Oribatida as a group are influenced by vegetational type more than by geographical locations, while the reverse is true for Collembola.

Key words: Oribatida, Collembola, species diversity, Egypt, vegetations, abundance

Introduction

Season, soil type, plant cover and intensity of soil cultivation may have a great influence on soil faunal diversity and abundance; this influence may override some often studied experimental factors such as the moisture content of the soil, the water holding capacity and the permeability for water and air (Andren & Lagerlöf 1983). Oribatid mites are often numerically a dominant group among the soil arthropods in all soil types. These animals inhabit a variety of habitats, such as soils, rotten wood, fresh and decayed litter, mosses growing on rocks and standing trees, tree trunks and earthworm tunnels (Aoki 1967; Thompson 1973; Bayoumi 1979; Al-Assiuty 1981; Khalil 1988). A number of authors have described the relationship between soil factors and microarthropod communities (Wallwork 1983; Hågvar 1984; Van Straalen et al., 1988) but in fact, soil factors may be influenced

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Until March 1994 Correspondence to: M. A. Khalil[2] by vegetational types while soil communities may be different at different localities due to geographical distribution patterns. These factors may be partly unravelled by studying similar vegetational types in different geographical areas. So, the purpose of this study was to test the hypothesis that vegetational type has a main influence on the abundance and community composition of soil microarthropods.

Materials and Methods

Sampling, site description and extraction

Sampling was carried out at monthly intervals from October, 1989 to September, 1990. Two different Governorates of Egypt were chosen: Al-Qalyoubia (Al-Qanater Al-Khahiriya city, 90 kilometres south of Tanta city bordering the Nile river) and Al-Behere (Rashid city, 120 kilometres northwest of Tanta city and located within the northern part of the Nile delta, close to the Mediterranean sea). Figure 1 shows a map of the locations. At each locality, two sampling sites of distinctive plant cover were selected. These were orchards cultivated with orange and banana trees. Twenty-four soil samples were collected from each of the four areas-viz., Al-Qanater Al-Khahiriya-orange, Al-Qanater Al-Khahiriya-banana, Rashid-orange and Rashid-banana. Sampling was conducted by means of a rectangular metal sampler 10 × 10 × 8 cm. Samples for soil annelids and macroarthropods were taken by hand-sorting, whereas the other microarthropods were extracted using the modified Berlese's funnel,

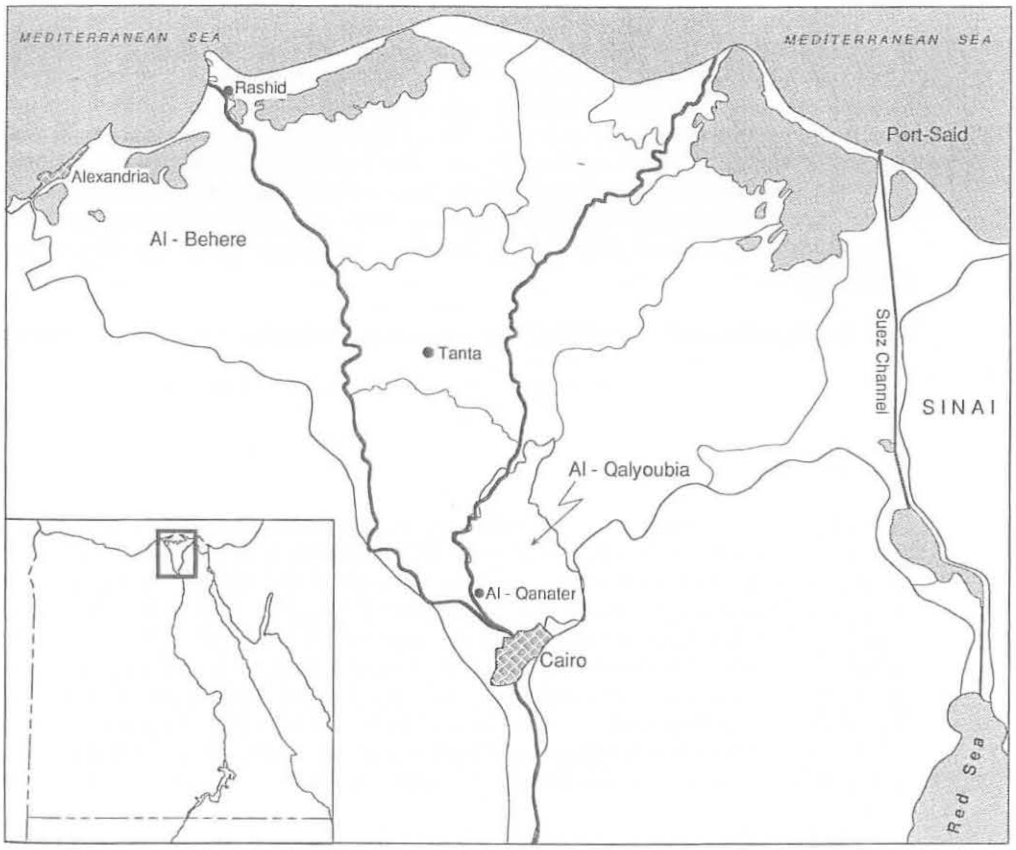

Fig. 1. Map of the locations of sampling sites (Rashid and Al-Qanater). The inset shows Egypt

as recommended by Balogh & Loksa (in Balogh 1958). Kühnelt (1961), Hussein (1972) and Al-Assiuty (1981) recommended the use of a 25 W electric lamp suspended 10 cm above each sample. Depending on the room temperature of the laboratory, the downward migration of microarthropods took place within three to six days. A small plastic container (5 cm diameter and 8 cm depth) containing a mixture of 70% isopropyl alcohol and ethylene glycol (9 to 1) was used to receive the separated fauna (Bayoumi 1978). The soil microarthropods were separated by means of a fine camel hair brush and with the help of an ordinary binocular stereomicroscope. It was preserved in labeled small glass vials filled with 70% ethyl alcohol for storage. The animals were cleared by transferring them into a watch class containing a mixture of 70% ethyl alcohol and a few drops of lactic acid (Balogh 1972) and then the watch glass was left open at room temperature in a dust proof cabinet. After a few days, alcohol was evaporated. The animals were retained in lactic acid for about one to two weeks, depending on the size and the degree of sclerotization of the specimens. To prepare the specimens for identification, temporary preparation methods were applied (Grandjean 1949). This process is made under a binocular microscope. Classification and identification of the collected soil fauna were carried out according to Willmann (1931), Sellnick (1960), Balogh (1972), Ghilarov & Krivolutsky (1975), Balogh & Mahunka (1980, 1983), Moursi et al. (1983) and Zaher (1986a, b).

Physico-chemical analysis

Temperature: The temperature of air and soil were measured with an ordinary and soil contact thermometer, respectively.
Soil moisture: Known amounts of fresh soil samples were dried at 105 °C for 24 hours. The percentage of the soil moisture was calculated as follows:

$$\%\ \text{water content} = \frac{\text{fresh weight} - \text{dry weight}}{\text{dry weight}} \times 100$$

Hydrogen ion constellation (pH): 10 g of air-dried soil was shaken with 25 ml distilled water for 30 minutes and pH was measured in the extract.
Soil conductivity: The electrode of the conductivity meter was rinsed with the same soil suspension after shaking four times through 30 minutes intervals. Before measuring, the instrument was calibrated with a 0.01 N potassium chloride solution which at 25 °C has an electrical conductivity of 1411.8 μS per cm.

Data processing

Abundances were evaluated for four categories of soil animals: oribatid mites, other Acari, Collembola and other fauna. The total number of individuals was determined per core, for each of the two sites, the two vegetational types and at monthly intervals. Due to heterogeneous variance, the data were not analysed for each core separately, but the counts were pooled over 24 cores, for each site, vegetational types and sampling time. For reasons of inadequacy of the data in March and June, these two months were omitted from analysis. For statistical analysis, three-way analysis of variance (ANOVA) was applied (Sokal & Rohlf 1981) using site (two levels), vegetational type (two levels) and time (ten levels) as factors. The three-way interactions among these factors were assumed to be absent, and were used as error terms for the F-tests. Oribatid mites were analysed using original data, while for other Acari, Collembola, and other fauna, data were transformed to $\log(x + 1)$ to achieve homogeneous variance. Community composition was determined throughout the period of study by the Shannon-Wiener index of diversity (Pielou 1974) which is one of the most common ecological indices. It may provide an indication of community stability unter the balance of nature and it may also respond differently to geographical, developmental, or physical factors. To allow a comparison of the four samplings, Sørensen's quotient of similarity (QS) was applied to the number of species and individuals of oribatid mites.

Results

The average values of air and soil temperature, soil moisture, pH and soil conductivity of the four studied areas are shown in Table 1. The sites appear to be rather similar with respect to these factors, except for conductivity, which is lower at Al-Qanater, compared to Rashid.

Table 1. Average values of air and soil temperature, soil moisture, hydrogen ion concentration (pH) and soil conductivity of the four studied areas

site	air temperature (°C)	soil temperature (°C)	soil moisture (% of fw)	pH	soil conductivity ($\mu S\ cm^{-1}$)
Al-Qanater orange	27.9	23.4	28.8	8.3	438.8
Rashid orange	27.7	20.9	28.8	8.4	619.0
Al-Qanater banana	27.9	23.6	28.8	8.3	445.0
Rashid banana	25.3	20.9	28.8	8.5	600.2

fw = fresh weight

Monthly fluctuations and relations to vegetational types and site

Oribatid mites: A three-way ANOVA (Table 2) applied to the mean number of individuals per core revealed that the effect of vegetational types on oribatid mites was considered significant as $p < 0.05$ but no significant differences among site-vegetation, time-vegetation or site-time interactions were observed. Fig. 2 gives a more detailed illustration of this result. At Al-Qanater and Rashid more oribatid mites were observed under orange vegetation than under banana (note the difference of scale).

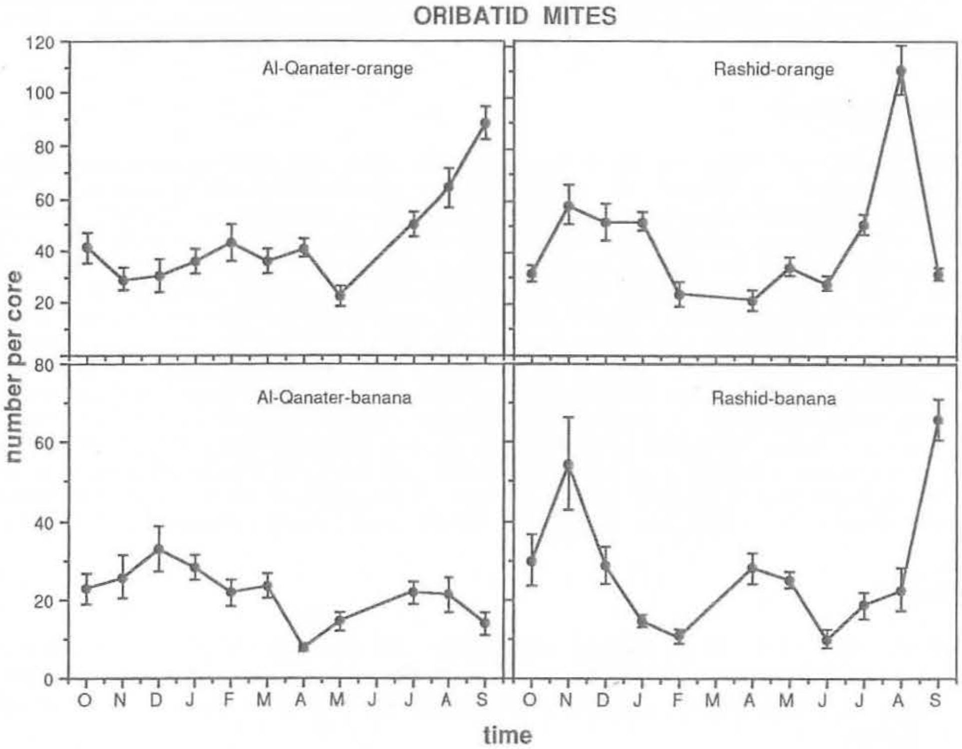

Fig. 2. Monthly fluctuation of the total number of oribatid mites collected from the four sampling localities

Table 2. Three-way analysis of variance for the mean number of soil fauna per core

source of variation	df	oribatid mites		other Acari		Collembola		other fauna	
		MS	F	MS	F	MS	F	MS	F
site	1	164.4	0.300 n.s.	0.302	4.809 n.s.	1.987	9.207 *	0.019	1.081 n.s.
vegetation	1	3584.7	6.547 *	0.300	4.787 n.s.	0.090	0.417 n.s.	0.157	9.084 *
time	9	450.8	0.823 n.s.	0.102	1.624 n.s.	0.232	1.074 n.s.	0.088	5.081 *
site × veg.	1	37.5	0.690 n.s.	0.217	3.458 n.s.	0.022	0.101 n.s.	0.100	5.764 *
veg. × time	9	325.8	0.595 n.s.	0.063	0.999 n.s.	0.194	0.897 n.s.	0.025	1.444 n.s.
site × time	9	207.2	0.378 n.s.	0.074	1.175 n.s.	0.230	1.063 n.s.	0.043	2.474 n.s.
error	9	547.5		0.063		0.216		0.017	

Oribatid mites were analysed using original data; for other Acari, Collembola and other fauna, data were transformed to log (x + 1). MS = mean square, df = degrees of freedom, F = F statistic.
n.s. = not significant: * $0.01 < p < 0.05$

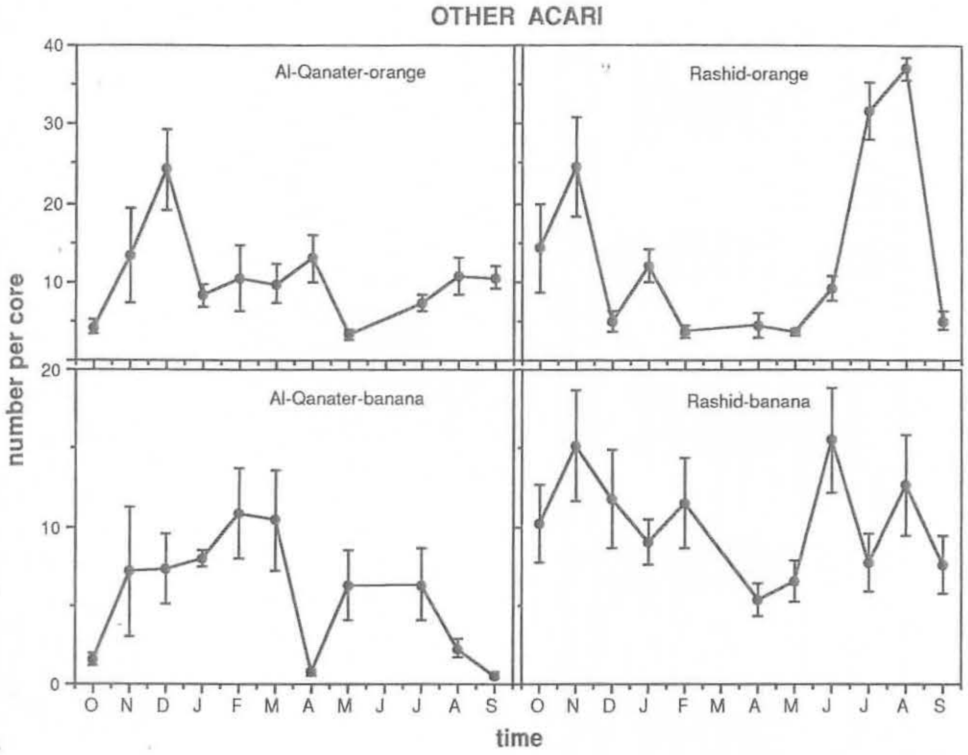

Fig. 3. Monthly fluctuation of the total number of other Acari collected from the four sampling localities

Other Acari: Other Acari showed no significant differences in site, vegetation, time or in the interactions among them. Fig. 3 displays the monthly fluctuations of the total number of other Acari. More or less irregular fluctuations can be deduced, without a clear pattern.
Collembola: The effect of site on Collembola was considered significant ($p < 0.05$) but there were no significant differences due to site-vegetation, vegetation-time or site-time interactions. Fig. 4 shows the monthly changes in abundance of the total number of Collembola which indicates random fluctuations with a prominent peak in February at Al-Qanater-banana. It can also be observed that there are more Collembola at Rashid-orange than at Al-Qanater-orange.
Other fauna: Both vegetation and time affected the other fauna and these effects were considered significant ($p < 0.05$). Results of the ANOVA also revealed a significant site-vegetation interaction but no significant differences due to site, vegetation-time, and site-time interactions. Fig. 5 gives a more detailed explanation of these results. Other fauna are more correlated with orange than with banana, and there are a large monthly differences among the four different sites.

Species composition

The oribatid mites extracted were classified into thirty genera and forty-seven species. Table 3 shows a list of oribatid mite species in the four sampling sites, and the total number of individuals collected throughout the sampling period. To allow a comparison between the sites, Sørensen's quotient of similarity (QS) for the four sampling sites was calculated

Table 3. List of oribatid mite species in the four sampling sites, and the total number of individuals collected throughout the sampling period

nr.	species	Al-Qanater orange	Rashid orange	Al-Qanater banana	Rashid banana
1	*Cosmochthonius reticulatus*	1	–	–	1
2	*Hoplophorella scapellata*	46	20	56	9
3	*Rhysotritia ardua ardua*	223	21	557	204
4	*Rhysotritia ardua pencillata*	6	1	60	16
5	*Javacarus kühneltii*	19	8	4	67
6	*Papillacarus aciculatus*	–	–	5	–
7	*Lohmannia turcumanica*	1	1	188	4
8	*Epilohmannia c. cylindrica*	124	23	139	30
9	*Epilohmannia p. aegyptica*	287	157	491	169
10	*Nothrus biciliatus*	182	247	4	42
11	*Cyrthermannia ezzatei*	148	6	248	21
12	*Niloppia sticta*	55	43	37	2
13	*Cilioppia difficilis*	69	20	1	–
14	*Cilioppia variance*	3	–	–	–
15	*Oxyoppia quadrifoveolata*	–	41	–	13
16	*Amerioppia hamidi*	130	2754	22	220
17	*Multioppia laniseta*	–	50	–	1
18	*Multioppia wilsoni*	70	286	28	40
19	*Striatoppia niliaca*	9	–	13	41
20	*Oppiella nova*	194	426	48	619
21	*Oppiella rossica*	14	–	–	29
22	*Fosseremus laciniatus*	–	–	4	–
23	*Lamellobatus h. aegypticus*	423	196	859	1912
24	*Tectocepheus sarekensis*	214	7	168	402
25	*Tectocepheus velatus*	266	27	69	53
26	*Tectocepheus alatus*	4	–	1	–
27	*Zygoribatula dermatoglypha*	69	124	337	40
28	*Zygoribatula longiporosa*	472	69	326	331
29	*Zygoribatula aegyptica*	–	3	–	6
30	*Zygoribatula undulata*	95	52	63	93
31	*Siculobata sicula*	25	3	2	1
32	*Scheloribates laevigatus*	21	–	–	4
33	*Scheloribates fimbriatus*	1872	344	975	1531
34	*Scheloribates transplicatus*	1	–	2	–
35	*Scheloribates zaheri*	1898	1895	203	513
36	*Xylobates lophotricus*	2822	2500	165	754
37	*Xylobates capucinus*	39	260	17	199
38	*Rostrozetes foveolatus*	1076	4	523	8
39	*Rostrozetes aegypticus*	45	–	3	5
40	*Galumna aegyptiaca*	1	–	–	–
41	*Galumna flabellifera*	822	81	284	22
42	*Galumna tarsipennata*	37	426	15	31
43	*Suctobelbella baloghi*	–	65	–	11
44	*Anachipteria aegyptica*	–	1	–	–
45	*Plakoribates multicuspidus*	–	–	–	8
46	*Archiphthiracarus ligneus*	–	1	–	–
47	*Berlesozetes aegypticus*	3	–	–	–

(Tab. 5). It may be concluded that the similarity is very high, ranging between 0.78 and 0.89. Concerning Collembola extracted, seven genera and eight species were classified. Table 4 displays a list of Collembola species in the four sampling sites, and the total number of individuals collected throughout the sampling period. Other Acari and other fauna

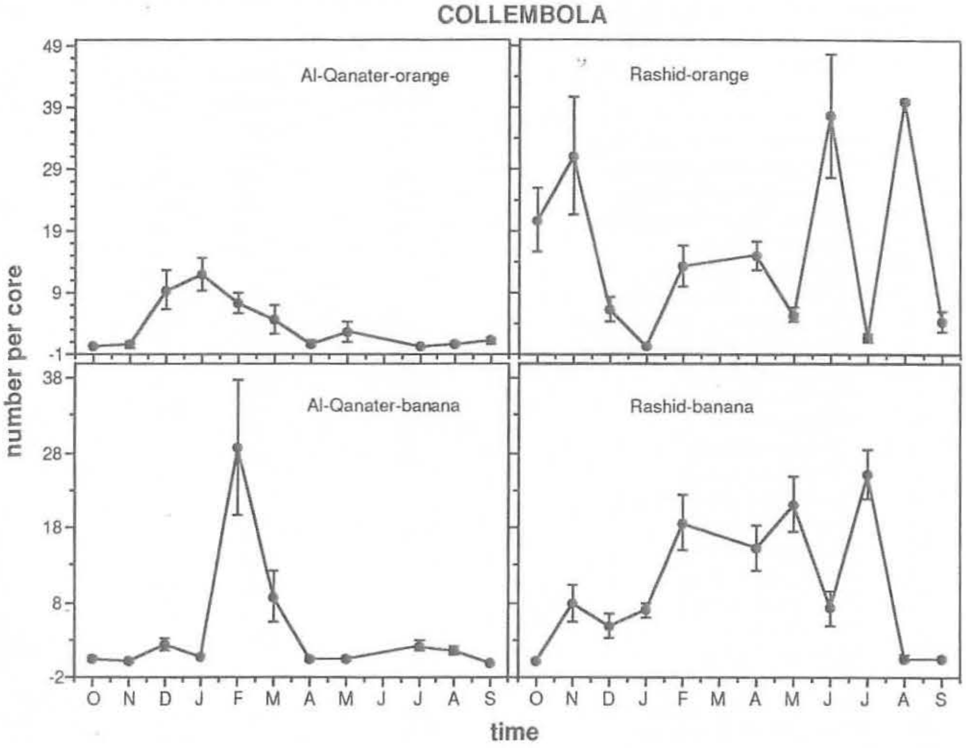

Fig. 4. Monthly fluctuation of the total number of Collembola collected from the four sampling localities

remained unidentified at the species level. The density of the total oribatid mites varied from 2465 to 4911 per m^2 and the average number at Al-Qanater is almost greater than at Rashid, while the density of the total Collembola varied from 390 to 1219 per m^2 and their average number at Rashid is greater than Al-Qanater (Table 6).

Species diversity

Regarding the species abundance relationship, a distinct fluctuation in the species diversity among the four sites is observed (Fig. 6). The Shannon-Wiener index ranged between 1.7 to 3 decits. At Al-Qanater-orange, the diversity value gradually increased during spring

Table 4. List of Collembola species in the four sampling sites, and the total number of individuals collected throughout the sampling period

nr.	species	Al-Qanater orange	Rashid orange	Al-Qanater banana	Rashid banana
1	*Friesea claviseta*	58	346	137	1023
2	*Hypogastrura denticulata*	25	2038	27	307
3	*Hypogastrura inermis*	9	89	90	137
4	*Entomobrya musatica*	13	10	10	18
5	*Isotomina thermophila*	736	398	749	908
6	*Sminthurides pumilis*	7	1	12	—
7	*Lepidocyrtus cyaneus*	88	43	75	203
8	*Cyphoderus bidenticulata*	—	—	5	9

Table 5. Sørensen's quotient of similarity for the four sampling sites based on the species group of oribatid mites

site & vegetation	Al-Qanater orange	Rashid orange	Al-Qanater banana	Rashid banana
Al-Qanater orange	1	0.777	0.888	0.826
Rashid orange	–	1	0.823	0.873
Al-Qanater banana	–	–	1	0.816
Rashid banana	–	–	–	1

Table 6. Average density of oribatid mites and Collembola in the four sites per m^2

site & vegetation	oribatid mites (m^{-2})	Collembola (m^{-2})
Al-Quanater orange	4911	390
Rashid orange	4234	1219
Al-Qanater banana	2465	460
Rashid banana	3105	1085

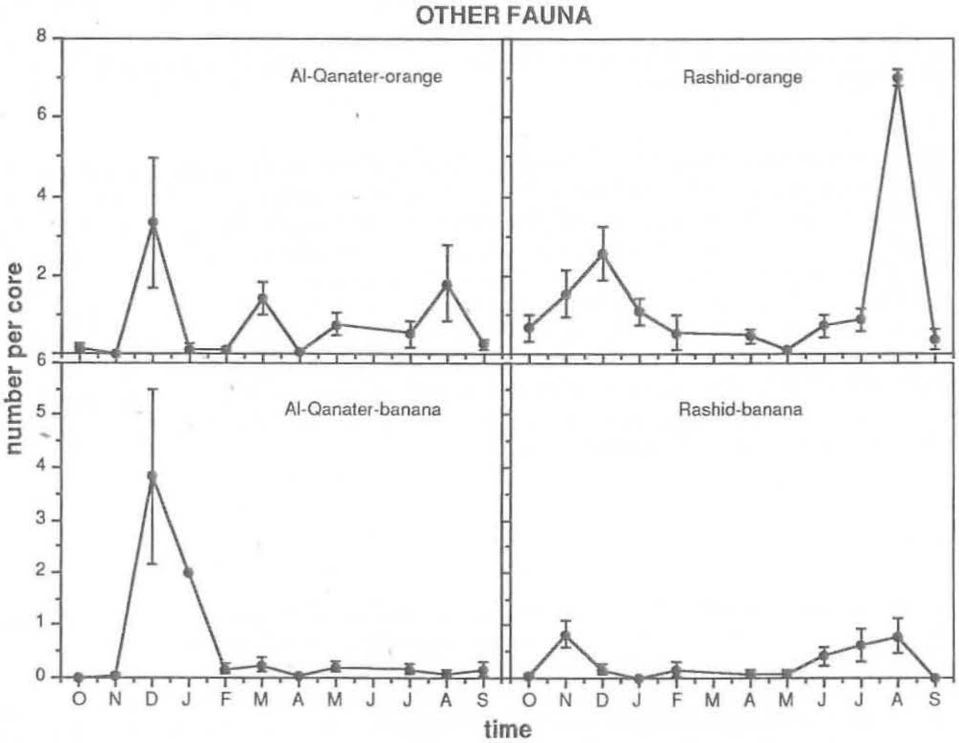

Fig. 5. Monthly fluctuation of the total number of other fauna collected from the four sampling localities

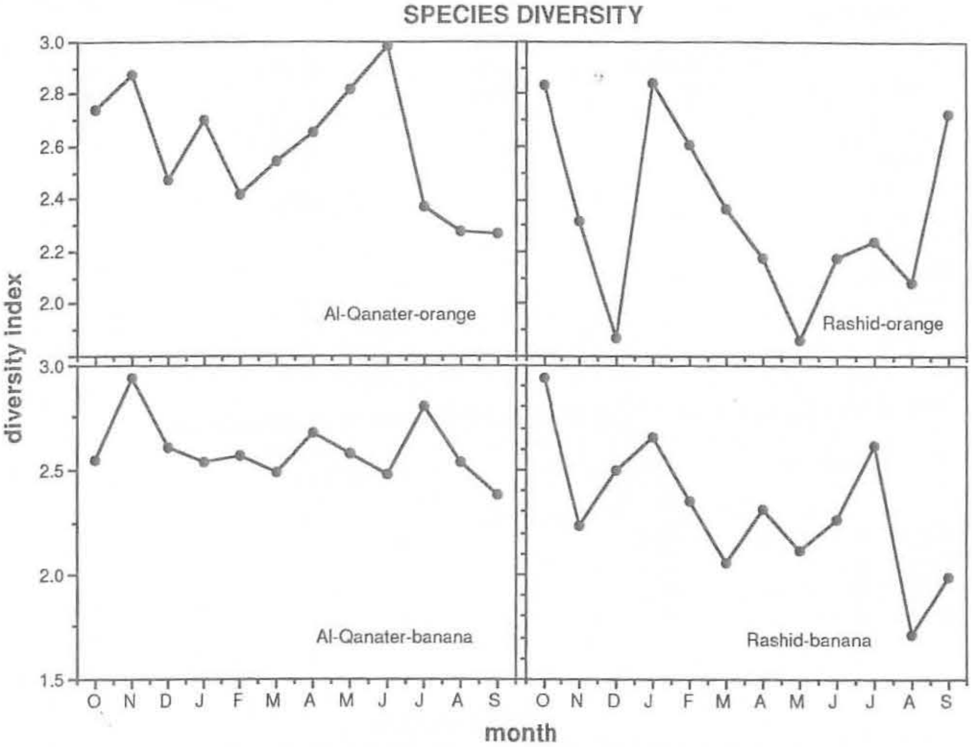

Fig. 6. Monthly fluctuation of the Shannon-Wiener diversity index (decits) of the soil, fauna collected from the four sampling localities

reaching a maximum value in mid summer which was followed by a distinct decrease until it reached the minimum level in September. At Al-Qanater-banana, species diversity showed its highest value in November and was more or less stable from December to July. Concerning species diversity at Rashid-orange site, a marked decrease was observed in December and then it rapidly increased to reach a maximum in January, followed by a gradual decrease till reaching a minimum in May. At Rashid-banana site, however, the maximal value of species diversity was noticed in October and then it became more or less stable from November until July but in August it reached its minimal value. So we can deduce from Fig. 6 that species diversity fluctuated through the year, but was more or less similar between different vegetational types at the same sites, and dissimilar between the same vegetational types at different sites.

Discussion

It has been supposed that a knowledge of the microarthropod communities associated with particular soil and vegetational types might provide a useful biological basis for soil classification, and that changes in community structure might be useful in detecting deleterious effects of management practises on soil fertility (Curry 1978). Monthly changes in population abundance of soil fauna have been studied in various regions and these studies have demonstrated seasonally stable populations (e.g. Lebrun 1969; Mitchell 1977) and seasonally unstable populations with peaks in certain periods of the year (e.g. Luxton 1981). The present study indicates that more oribatid mites could be observed in orange orchards than in banana orchards. Accordingly, the effect of vegetational type on oribatid mites was significant. This result is in good agreement with Trehan (1945), Van de Bund (1970), Abdel-Hamid (1972), Anderson (1978), Curry (1978), Hågvar (1984) and Walter (1985). However, it is not in accordance with Wood (1967a, b) who stated that population density of oribatid mites cannot be correlated with the type of vegetation.

It was surprising to find in our results that other Acari showed no significant differences in site, vegetation, time or in the interactions among them and the monthly fluctuations of the total number of other Acari were more or less random; Collembola revealed a significant difference to site only and not among the other categories, the monthly fluctuations of the total number of Collembola seemed to be random with a large peak in February at Al-Qanater-banana and more Collembola in Rashid-orange than Al-Quanater-orange. In a study by Wood (1967a), population density of oribatid mites, other Acari and Collembola could not be correlated with gross features of the habitat such as humus form, soil type and type of vegetation. This author also added that a stronger correlation existed between the feeding habits of the dominant microarthropods and the macro-environmental factors. Moreover, Lagerlöf & Andren (1988) concluded that abundance of total Acari did not differ significantly between crops.

In an earlier study, Curry (1978) concluded that no obvious relationships could be detected between collembolan communities and vegetational types. These observations are in conformity with our results. However, Poole (1961, 1962 & 1964) has recognized that only a few species of Collembola showed significant relationships to some properties (depth and mass of organic matter),while Hågvar & Abrahamsen (1984) have studied the relationships between collembolan abundance and soil chemical properties. The latter authors emphasized that the highest number of significant correlations were with pH and base saturation, Ca, Mg & Mn and Collembola species were relatively poor indicators of soil chemistry.

Other fauna displayed significant effects of vegetation, time and site-vegetation interactions and showed more correlation to orange than to banana. The monthly fluctuations of the total number of other fauna revealed striking differences at four different sites and showed a winter peak which may be attributed to moisture conditions. Other workers have attributed the differences in the biotic structure of microarthropods among different habitats to the variation in the species composition and density of fungi present in these habitats (Al-Assiuty 1981). Some microarthropods may be influenced more by the distribution of preferred substrates (e.g. lichens) than by any response to microclimatic factors (Wallwork 1983).

Our results have shown that the highest species number of oribatid mites were recorded during the dry season at different sites, so this group of animals must consist of drought-resistant species. This result is in good agreement with Wafa et al. (1965), who revealed that some oribatid mites tend to exist in deeper soil strata where humidity is greater, while others were more tolerant to dryness as they preferred the surface soil layers. They classified oribatid mite species into three main categories according to their vertical distribution viz., deeper dominating species, surface dominating species and median layer dominating species. All these categories of species did not change their behaviour due to change of season, but they actually stayed in the layers they preferred during the whole year. So, seasonal variations in oribatid densities were obvious in some cases and unnoticeable in others. However, the present results are in disagreement with Block (1966) who found that the minimum population of oribatid mites was present during summer. Moreover, Kaneko (1985) verified also that seasonal fluctuation in population abundance may be shaped by population decrease during adverse conditions such as drought in summer. But, our conclusion is supported by Wallwork (1983) who pointed out that groups consisting of species with wide tolerances to fluctuations in, say, moisture and temperature will clearly cross more habitat boundaries than groups comprising species with only narrow tolerances to these factors. Moreover, in forest habitats, Teuben & Smidt (1992) have also found that the arthropod species distribution and abundance were related to small differences in forest characteristics.

Regarding the species diversity index (H) of the soil fauna collected from the four sampling localities, the present data showed a stable variation among them throughout the study period. These stabilities in the communities may be related to the stable population in the study area. On the other hand, Kaneko (1985) found that the differences in both amounts and vertical structure of soil organic layers between the plots were significant factors contributing to the difference of oribatid mite communities in species diversity. In contrast Lagerlöf & Andren (1988) traced a low value of species diversity (H) to the greater differences existing between years than between crops. It can be concluded from Fig. 6 that species diversity was similar to some extent, between different vegetational types at the same sites, and dissimilar between the same vegetational types at different sites. This deduction is in good accordance with Anderson (1978) who showed a positive correlation between oribatid mites species diversity and the habitat diversity. As concerns the population size, the results showed that the annual population size of the oribatid mites at the four different localities ranged from 2465 to 4911 ind. m^{-2}. Similar results have also been reported earlier (Tarrad 1986). Moreover, the population size of Collembola varied from 390 to 1219. This observation is in accordance with Hågvar & Abrahamsen (1984). They determined an abundance of 1000 ind. m^{-2} in at least one habitat. In conclusion, the present results suggest that Oribatida as a group do respond more clearly to vegetational type than Collembola. Microhabitat specialization may be developed more extensively in the Oribatida.

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